DOCUMENT RESUME

ED 190 158 IR 008 694

AUTHOR Gerjuoy, Herbert G.; Owen, T. Gerald
TITLE On-Line Forecasting Capabilities: Futurscan and Its Alternatives.
PUB DATE Mar 80
NOTE 25p.; Paper presented at the National Online Information Meeting (New York, NY, March 25-27, 1980).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Data Bases; Futures (of Society); Information Retrieval; Long Range Planning; *Online Systems; *Prediction

ABSTRACT

This paper provides an overview of the field of online information retrieval systems whose databases are programmed to predict future events. These systems rely on data of past events and use mathematical techniques such as regression analysis and statistical probability to provide forecast data. The history of these systems is traced through the advent of the IBM QUICKTRAN program in 1967 and descriptions of 13 other predictive systems. Recent trend impact analysis studies have led to the development of INTERAX and FUTURSCAN, which offer sophisticated and complex predictive online capabilities. A list of 15 references is provided. (RAA)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED190158

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

ON-LINE FORECASTING CAPABILITIES:

FUTURSCAN AND ITS ALTERNATIVES

Herbert G. Gerjuoy *and* T. Gerald Owen

23 January 1980

A paper prepared for presentation at the

National Online Information Meeting

New York City

March 1980

PROGRAM STRATEGICS, inc.
Box 7-585
West Hartford, Connecticut 06107

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Herbert G. Gerjouy

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Report FEC9/1

IR008694

528

On-Line Forecasting Capabilities: FUTURSCAN® and Its Alternatives

Herbert G. Gerjuoy, Program Strategics, inc.

and

T. Gerald Owen, The Futures Group

Introduction

Among data bases, there is a special ecological niche for futures-oriented data bases. This special niche relates to the—

- futures orientation of their contents;
- exceptional role of computation in the generation of
  - the contents of many records,
  - output, i.e., results of data base usage.

Content: Usefulness more important than accuracy. Unlike other data bases, futures-oriented data bases do not refer primarily to what has already occurred; rather, they deal with possible or probable future occurrences. An example, perhaps absurd, of such a data base would be a bibliographic data base whose records pertained to future publications, say, books that might be published in the year 2000.

We would not expect to encounter a bibliographic data base devoted to books to be published in the year 2000 until, perhaps, the year 1998 or 1999. By then, such a data base might have some utility: by then, its contents might be more than interesting or possibly entertaining speculation.

This illustrates a key point about futures-oriented data bases: although their contents pertain to the future, they are used, like any data base, in the present, and their contents must therefore exist in the present and be useful in the present.

It is usefulness in the present that is a fundamental desideratum,

not accuracy. Accuracy is, of course, generally desirable, but even highly inaccurate information about the future may be quite useful. The prophet Jonah was inaccurate when he prophesied to the people of Nineveh that their city would be destroyed: Nineveh was not destroyed. Though his prophecy was inaccurate, the people of Nineveh found it useful: it caused them to repent, and just this was why the city was saved.

Rarely do users search a data base because the search is an end in itself, although we may, I suppose, conceive of a new art form whose artistic productions are esthetically satisfying data base searches. Rather, users search data bases because the results of the search will contribute to some process that transcends the search itself. For example, the search results may contribute to planning, to evaluation, or to decisionmaking. It is hard to conceive of how search results might contribute to some process without thereby changing it, that is to say, causing the outcome to be different from what it would have been had the search not been performed or had the search results been different. If a data base contains useful information, then using it causes the outcome to be more satisfactory to the user than had the data base not been used. In particular, a useful futures-oriented data base is one that contains information about the future that contributes positively to, for example, planning; use of the data base makes the planning better planning. Such a data base need not contain accurate information about the future. But the information, such

as it is, must be relevant--relevant to the purposes of the data base users.

It is fortunate that the contents of a futures-oriented data base need be relevant rather than need be accurate. Science does provide us with the basis for reasonable expectation of great accuracy in prediction about some circumscribed matters, such as the timing of eclipses. However, the sorts of events that interest historians, the course over time of economic indicators, the occurrence or non-occurrence of technological breakthroughs--these are the sorts of matters about which it has long been difficult to be accurate when making predictions, and no sign is visible of a method that may be expected greatly to enhance accuracy in the near future. Many of the sorts of matters that appear very difficult to forecast accurately are also matters of great interest to many users and potential users of futures-oriented data bases; they are highly relevant to planning, decisionmaking, evaluation, etc., in government, business, science, etc. The double use of "etc." in the preceding sentence is a deliberate effort to convey a sense of unbounded applicability and application of information about future matters that are difficult to predict accurately.

How can information of dubious accuracy be useful, except fortuitously? Information about the future may be cautionary, like Jonah's prophecy. It may help us prepare for an unlikely catastrophe or an unlikely bonanza, where the magnitude of the possible costs or rewards justifies preparation despite their improbability. Inaccurate information about the future may help clarify present

values or attitudes. We may learn about ourselves from our reactions to the prospect of a particular future event--it matters not here whether the event does ultimately come to pass.

Computation: Future on-line services will combine search-retrieval with computation. So much for the peculiarity of futures-oriented data bases with respect to content. They are also remarkable because of the exceptional role of computation in their generation and use.

There are trade-offs between information storage and computation somewhat like the trade-offs between hardware and software, or between reasoning things out and empirical observation. Therefore, the familiar distinction between on-line data base technology and on-line computation technology has been more a convenience than a fundamental separation of categories. As our search algorithms become more complex, and as our computational programs demand greater bodies of data be input to them, the convenience of the distinction declines. There appears to be convergent evolution toward powerful user-oriented systems in which great bodies of data housed in many records may be subjected to complex selection and manipulation prior to output display.

Most on-line information retrieval systems are evolving toward this conjunction of information retrieval and computation from, as might be expected, the direction of information storage. For example, the development of content analysis will soon add a very considerable computational component to the on-line retrieval of information from text sources. However, futures-oriented data bases generally have a different heritage. Their ancestry, though mixed, is largely in the computational family.

Some On-Line Forecasting Capabilities

A notion of the range of past and present on-line forecasting capabilities is afforded by the following list of close and distant relatives. The list contains items selected to illustrate the various strands that have come together in modern on-line forecasting, and so it neither includes only important programs or systems nor includes all that are important. Entries in the list are roughly in chronological order of their availability.

- IBM QUIKTRAN Growth Rate Program[1] and Capital Investment Analysis Program[2]
- General Electric Mark I Time-Sharing Service GROWTH * * * program[3]
- GPSS[4]
- New York State County Data Inquiry and Analysis program procedures PROJT1[5] and PROJT2[6]
- Interactive Sciences Corporation's EA 1000,[7] RGR/10,[8] TRND,[9] TRNDCY,[10] LESSEE,[11] and LESSIM[12]
- trend impact analysis[13]
- Scientific Time Sharing Corporation's ACT*PLUS[14]
- probabilistic system dynamics[15]
- Northwestern University Vogelback Computing Center's SPSS Procedure SURVIVAL[16] and SPSS Subprogram SPECTRAL[17]
- IFPS[18]
- AUTOBJ[19]

Algorithms for curve fitting and projection. Already in 1967 the QUIKTRAN Growth Rate Program[1] was available for projecting a future value from a present value and growth rate, or for calculating growth rate from a set of historical values. For input data in equispaced periods, the General Electric Mark I GROWTH * * * program[3] could also be used to calculate growth rate.

Somewhat more elaborate was ISC's TRND.[9] This program was designed to analyze data for simple trends. It could perform a least-squares fit to any of three equations: linear, semi-log, or log-log. ISC's TRNDCY performed a similar analysis that sought to detect periodicities in the historical data.[10]

Even more elaborate is the SPSS Subprogram SPECTRAL. Like TRNDCY, it focuses on periodicities. However, by selecting from a variety of options, the user can investigate either periodicities in a given time series or bivariate linkages between two time series. Other options give the user the ability to choose among many alternative computational approaches. As many as 200 variables can be dealt with in one run.[17]

The Northwestern University computing center also has available ARIMA, a program for performing a Box-Jenkins analysis. A Box-Jenkins program is even more sophisticated and elaborate than SPECTRAL. AUTOBJ, on INFONENT, is a very sophisticated Box-Jenkins system. AUTOBJ uses current and historical data to generate forecasts. Many alternative algorithms or models can be chosen, either by the user or by the system, using a master algorithm.[19]

The QUIKTRAN Growth Rate Program, GE's GROWTH * * *, ISC's TRND and TRNDCY, SPSS Subprogram SPECTRAL, and Box-Jenkins analysis exemplify a sort of computation that is still used extensively in futures-oriented on-line operations: past history data are examined and tested for some specified regularity (such as exponential growth) or the system determines which of several alternative regularities best characterizes the data. The algorithm may also be used to extrapolate

the data into the future, assuming that the regularity detected in the past-history data will persist unchanged.

What is more or less lacking in or in association with these programs is a body of stored information constituting a data base. They are essentially computational: they do not retrieve previously stored futures-oriented information; rather, historical data input to an algorithm are used to compute futures-oriented output.

More in keeping with the advanced systems available today would be to complement the computational capability with access to a large numeric data base of the sort discussed in our sister session, "Designing and Using Numeric Databases." The data base would contain many time series of historical data that could be projected into the future using the projection algorithm. An example of such a data base that was available early for use in conjunction with computational programs is the National Bureau of Economic Research Data Base, a set of over 1500 time series that in 1972, for example, was available to subscribers to ISC's time-shared system.[20]

Systems with stored data. It was soon recognized that a forecasting system or program should be able to refer to data in storage on line, and so quite early such data became available and were placed in direct association with forecasting algorithms, rather than being, like ISC's NBER data base, merely another facility available to the same set of subscribers.

For example, the New York State County Data Inquiry and Analysis System was a time sharing information storage and retrieval system

that provided users with immediate access to and analysis of large amounts of data.[21] The System's Program Procedure PROJT1 extrapolated a specified data element for a given number of years based on a given annual rate of change,[5] and PROJT2 extrapolated based on given historical information.[6]

The Boston Company Investment and Research Technology, Inc. provided to ISC's subscribers the RGR/10 program package, which had housed in it along with its computational programs a 40-quarter data base covering 700 companies.[8]

RGR/10 was basically a regression analysis package. Regression is a common technique in futures-oriented computation. Typically, a regression is found or assumed relating past time series data. Then, if the predictor variables in the regression can be projected into the future by some other means, they can be used to predict the values of the dependent variable. Alternatively, the values of the dependent variable can be predicted directly from past history data already available, if the regression involves time-lagged relationships. In either case, it must be assumed that in the future the regression will be the same as it was in the past.

Probabilities. Because inaccuracy is not uncommon in forecasts of great interest to users of futures-oriented on-line services, it is rarely appropriate that forecasts or projections be provided apodictically, as if they were uncertain, without provision of an estimate of their likelihood of proving correct. The computational programs and systems discussed up to this point either do not provide such an estimate or provide one of only marginal utility, which

is not surprising considering that the estimate is ordinarily based on a statistic computed for a rather different purpose.

Regression analysis, for example, regularly generates a measure of the strength of regression--the goodness of fit of the regression relationship to the past data. A similar statistic is often generated by other curve-fitting programs and systems. More sophisticated systems may also perform statistical tests of the significance of the relationship or trend, tests that yield an estimate of the likelihood the observed trend was merely a chance fluctuation in a statistical universe in which there is no underlying trend. Such an estimate, like the measure of goodness of fit, can be used as an indication of the accuracy of a forecast based on the observed trend. But at best we have here an upper bound estimate: the accuracy of the forecast or projection can scarcely be expected to be better than the accuracy with which the relationship on which it is based describes the past data. However, the forecast or projection may be much less accurate. The future does not always faithfully mirror the past. What is needed is some estimate not only of how reliable is the past trend but also how likely it is that the trend, such as it is, will continue unchanged into the future. Advanced systems today do provide such an estimate, and to do so they turn to a very different approach than the sorts discussed up to this point.

Already available in 1967 was the QUIKTRAN Capital Investment Analysis Program, which made possible on-line calculation of year-by-year depreciation, salvage value, debt interest due, cash return after taxes and interest, rate of return, probability of retirement,

and overall return.[2] In this program, the overall return was calculated by multiplying a retirement probability factor (which could be user-supplied) for each year by the calculated return for that year, then summing year by year across all years.

User-supplied estimates of the likelihood of events that help determine a future outcome may be entered in systems of greatly varying complexity. Among the more complex applications where this may be done is GPSS. Already in 1969, IBM's GPSS/360, a sophisticated technique for simulating complex systems, permitted "statistical transfers," in which the probability in the simulation of a particular transaction involving a particular entity was determined by a user-supplied decimal fraction. Thus, it was possible to generate not merely a single simulation outcome, but rather a distribution of outcomes depending on the probabilities of simulation events--probabilities that had been specified by the user.

Actuarial applications are among the more common futures-oriented applications that are routinely probabilistic. For such applications, a special programming language has been developed, ACT*PLUS, itself based on APL.[14] Also available for survival analyses is the SPSS Procedure SURVIVAL.[16]

The general approach to forecasting developed by Box and Jenkins also makes provision for noise or uncertainty in a variety of ways. In particular, there are sophisticated approaches to deciding which of several very general alternative approaches to forecasting may be most appropriate in a given case.[22]

A sophisticated and powerful modern applications system that

can generate probabilistic projections is IFPS, provided by EXECUCOM. This is a system for computer-assisted planning designed for use by persons with no more than modest familiarity with computers or on-line operations. The system permits the user to utilize an English-like syntax to formulate a model or solve a problem. Projections can be produced that are probabilistic; they require user-supplied probability estimates for model parameters such as price or market share. Where the values of continuous functions are to be supplied by a user, the system interpolates linearly between values supplied for particular points. The system also readily accommodates "what if" modifications of input values, so the user can readily determine how alternative courses of action or external conditions might affect outcomes. A sophisticated and unusual feature of the system is its "goal seeking" capability, which permits the user to specify an outcome and then determine how input values need be adjusted to achieve that outcome. The IFPS system also accommodates data files. However, there is at present no on-line body of public data available for search and utilization.[18]

Predicasts; text giving event probabilities. Predicasts, Inc. provides an excellent on-line service giving users access to predictions by expert statisticians and economists. Forecasts which have appeared in over 1000 publications are analyzed and condensed. In addition, Predicasts's Research Group provides Composite Forecasts that are "best" estimates integrating the published forecasts and sophisticated mathematical projection. A typical forecast abstract specifies what it is that is being forecasted, e.g., sales by appliance and

tv stores of telephone answering devices, giving quantities for specified years, e.g., thousands of units for 1978 to 1984, provides the bibliographic source of the forecast, and gives the explicit or implicit annual growth rate indicated by the forecast. A Basebook provides a great many corresponding historical time series, and the Composite Forecasts provide both historical and future time series.

Futurists customarily make a distinction between two sorts of data:

- Time series or indicator data; data of this sort are a series of time-dependent values, such as quantity of pig iron produced in the United States year by year. It is for data of this kind that trends can be identified by methods like polynomial curve fitting, autoregression, or spectral analysis.
- Event data; data of this sort give the occurrence or non-occurrence of what can occur once and only once. An example of an event would be the first landing of humans on Mars. An event may be represented by a step function that has the value 0.0 until the event occurs; thereafter it has the value 1.0. Two quantities are associated with an event: (a) the time of its occurrence, if it occurs--a single value, and (b) the probability of its occurrence--a time-dependent variable.

By definition, a future event has not yet happened, and so no historical time series contains it. In many cases, it is inappropriate to rely on the sorts of trend projection techniques discussed above when seeking to forecast future events or their probabilities. However, events are often of great interest to users of futures-oriented on-line systems, either for their own sakes or because they may have powerful impacts on trends. Because, as noted above, forecasting is far from certain in many important cases, what is usually desired is not merely an estimate of the date of occurrence of an event but rather estimation of how its probability of having occurred

will grow with the passage of time. Both the retirement probability estimates used by the QUIKTRAN Capital Investment Analysis Program and GPSS statistical transfer probabilities may be regarded as estimates of the probabilities of events, in the sense that futurists use the term. Event probabilities are also considered in the more complex applications of ACT*PLUS, the SPSS Subprogram SPECTRAL, and Box-Jenkins analysis.

In the on-line file, PROMT, Predicasts provides estimates of the probabilities of future events. PROMT contains brief abstracts of futures-oriented materials that have appeared in any of a broad spectrum of popular and technical publications. Many such materials contain forecasts. Therefore, if, for example, one sought an expert opinion about when man is likely first to land on Mars, one might search the PROMT file with the subject term, "MARS." However, few forecasts, even by scientists, are couched explicitly in probabilistic language, and even when all concerned recognize that a forecast is uncertain, it is liable to be stated apodictically. Therefore, many of the forecasts that may be retrieved from the PROMT file do not have probabilities associated with them. Nevertheless, PROMT is a searchable on-line file containing quite a few and an appreciable density of event forecasts, and therefore it clearly meets a need not readily met by other on-line services.

Trend impact analysis. A significant step toward the bringing together of the diverse strands of development touched upon above was the development of trend impact analysis by The Futures Group, Inc. Trend impact analysis was not originally an on-line system. Rather, it was a program package that permitted the user to generate

trend forecasts that more or less took into account the impacts upon them of critical future events. To do this, trend impact analysis typically proceded in two stages and made use of three sorts of data files. In the first stage, a file of historical time-series data was referenced. The time series was projected into the future using an algorithm whose sophistication and complexity was less than that in, say, the Box-Jenkins system, but greater than that in a typical univariate curve-fitting algorithm. Some 13 alternative two-parameter functions could be tried, and the one best fitting the past history data could be selected for use in extrapolation. The program did not give equal weight to all the past history data; rather, greater weight could be given to data closer to the present or otherwise considered more reliable. Upper and lower bounds could be set to the possible extrapolated or fitted values, and the function selected could be restricted to one that gave results that fell within the specified bounds. Alternatively, a function could be used that gave results outside the specified limits, but the trend actually projected would "flatten out" when the estimated values reached the specified boundary. The user could explicitly specify that a particular function be used regardless of the goodness of fit, or one or more functions could be excluded.

The output of the projection or FIT stage next became input to the second stage, which was the heart of the trend impact analysis. Alternatively, at this point the user could provide his own alternative projection. In the second stage, two additional files were referenced: a file of events and a file of event impacts. The event file contained text describing each event, plus numeric entries giving each event's

probability for each of one to five specified years. Probabilities for other years were extrapolated or interpolated, assuming that all events had probability 0.0 in the immediate past, i.e., that all events were future events.

The event impact file specified how each event, if it occurred, would impact the given future time series. These impacts were specified using a flexible five-parameter system, with three time parameters and two magnitude parameters. Impacts could be expressed either in absolute terms or in terms of proportions of the then current "baseline" predicted trend value--the value before any event impacts were added or subtracted. The impacts were summed algebraically for a given year to give a composite or expected impact for that year. The same summation was performed year by year, taking into account the various alternative years that the same event might occur, and taking into account the time-dependent course of the impacts of an event, once it did occur, which might include a specified delay or "lag" before the onset of any impact due to that event. Because the events were considered probabilistically rather than apodictically, their impacts were also probabilistic. The program output included not only the expected value of the future trend but also upper and lower quartiles for the probability distribution of possible outcomes.[13]

INTERAX. The original trend impact analysis program package was one of the ancestors of the INTERAX system developed by Selwyn Enzer of the University of Southern California Center for Futures Research. For his system, Enzer combined trend impact analysis

with cross-impact analysis. Cross-impact analysis makes it possible for the user to take into account possible mutual impacts among the events that influence the trends or time series. Cross-impact analysis adjusts the probabilities of future events to take into account how these probabilities might be affected by the prior occurrence of the other events under consideration.

INTERAX is presently available on-line to subscribers. There are accompanying data files containing about 50 trends and about 100 events and their probabilities over time, plus a large body of cross-impact data.[23]

INTERAX, for all its sophistication, by no means provides the user with the capability to simulate a complex system and project its behavior into the future. This is the sort of capability embodied in GPSS. A natural extension of INTERAX would be its embodiment in the context of a more general simulation system. If, in addition, a large body of on-line searchable futures-oriented text and numeric material were provided, a system would have been created that might be expected to meet the needs of users for some time to come.

FUTURSCAN. The original trend impact analysis program package developed by The Futures Group has been extensively augmented and improved. It is now part of the on-line FUTURSCAN system, a service of The Futures Group available the General Electric Mark III time-sharing service. One major computational extension was the addition of cross-impact analysis.

FUTURSCAN may be used in association with specialized data bases. Presently available are the Consumer, Pharmaceutical, and

Hospital PROSPECTS® data bases. Each of these data bases contains the three sorts of files used in trend impact analysis: historical time series, event texts and probabilities, and event impacts on trends. In addition, the data bases contain forecasts for each of the trends produced by applying the trend impact analysis program (with the event probabilities adjusted by cross-impact analysis) to the stored data about the historical time series, event probabilities, and event impacts. There are about 300 time series currently available to subscribers and about twice as many events with their associated text descriptions, probabilities, and impacts on trends. Many events, of course, are assumed to impact more than one trend, and all trends are assumed to be impacted by more than one event. In general, the impacts of an event on one trend does not constrain its impacts on any other trend.[24]

There have been a number of smaller but nevertheless important enhancements as trend impact analysis has evolved into FUTURSCAN. The curve-fitting capability is now considerably more flexible, and the system is oriented toward planning as well as forecasting applications by users with no more than modest familiarity with computers or on-line operations. The system is completely interactive. It encourages exploration of how modification of input values affects outcomes. The user can copy the shared data in the public data bases into a private work space and modify or add to the data. Temporary modifications in either public or private data can be made while working on-line, without permanently altering stored data. Where events correspond to alternative courses of action,

or to alternative external conditions, the system vividly displays the impacts of such alternatives on the specified future time series.

The body of public data is sufficiently small that it can be readily accessed without sophisticated search capabilities, which are not provided. However, it may be hoped that in time the body of public data will grow, and, as it does so, at least a simple key-word search capability will be added to the system.

FUTURSCAN, like INTERAX, does not provide the user with the capability to simulate a complex system and project its behavior into the future. At The Futures Group, progress has been made in the direction of providing this capability in connection with the development by The Futures Group of probabilistic system dynamics. This is a direct extension of system dynamics, as developed in the 1950's by Professor Jay Forester of the Massachusetts Institute of Technology. To system dynamics, probabilistic system dynamics adds probabilistic rather than inevitable flow through the dynamic system, plus cross-impacting of event probabilities, as in FUTURSCAN.[15] Thus, probabilistic system dynamics takes into account a greater range of cross-impacts than does present-day FUTURSCAN, where, for example, interactions between different time series are not explicitly considered.

Probabilistic system dynamics is not presently available as an on-line system, or even as a resident program package. Rather, a new system simulation must be programmed afresh for each application. It is to be hoped that FUTURSCAN will evolve toward providing the sort of full simulation capability now offered by probabilistic

system dynamics. Presently, FUTURSCAN and INTERAX would appear to be among the most sophisticated and flexible on-line forecasting systems available. It is to be hoped that they will continue to grow as the state of the art advances. The two major areas of growth to be anticipated are in data file extent and manipulability and in the flexibility and sophistication of their system simulation capability.

FUTURSCAN and INTERAX compared. The differences between FUTURSCAN and Enzer's system largely reflect differences in philosophy. Enzer's system favors construction of a single "scenario" developed by choosing a single set of possible future occurrences--a sort of single run of what would with repeated runs become a Monte Carlo solution. Indeed, Enzer's system generates probabilistic output by Monte Carlo methods. The trend impact analysis program developed at The Futures Group arrives at a direct, analytical solution for the trend projection, and therefore favors production of an "average" future, rather than a single, possibly idiosyncratic scenario. The forecast generated by FUTURSCAN's program is in a sense the limit that would be attained by an infinite number of Monte Carlo runs of a program like Enzer's. The second, third, and fourth moments of the distribution of future trends are also generated analytically by the program written at The Futures Group, and from these moments various upper and lower distribution bounds are calculated, such as the upper and lower quartiles.

Enzer's INTERAX system, by virtue of its use of single, Monte Carlo runs rather than an analytic solution, permits the user to

interact with a single run while it is taking place in simulation time. The user, observing an interesting or threatening trend or event, may halt the simulation, alter the conditions, and then bid the run proceed. The use of Monte Carlo methods also makes it possible for the user to take note of very extreme trend outcomes, at the very edge of the distribution of possible trends, and scrutinize them in detail to determine the sorts of combinations of events that may lead to such extreme cases.[23] A FUTURSCAN user, by contrast, might interactively adjust the probabilities of impacting events to force the occurrence of an extreme scenario, and then note the effect on the trend.[24] The difference is that Enzer's approach favors discovering an extreme trend and learning what events together could give rise to it, while FUTURSCAN favors identifying extreme events and learning how together they would affect the overall trend. This does not appear to be a profound difference.

Whether the approach favored by The Futures Group or the approach favored at the University of Southern California is more suitable to a particular user's needs depends largely on whether the user wishes to look at a few, particular possible futures (which would favor using Enzer's program) or wishes to see overall statistics about the expected future trend and the characteristics of the distribution of alternatives (which would favor using FUTURSCAN's trend impact analysis).

Another, less fundamental difference is that Enzer's program intimately combines trend impact analysis and cross-impact analysis, so that they both are necessarily performed together, while the

system developed at The Futures Group permits the user to cross-impact events without considering the impacts of events on trends, or vice versa.[23,24]

References

1. QUIKTRAN Financial Programs. White Plains, N.Y.: IBM Information Marketing, 1967. Pp. 13-15.

2. Ibid., pp. 16-24.

3. Mark I Time-Sharing Service Program Library General Catalog (rev.). Publication 228116A. Bethesda, Md.: GE Information Service Department, July 1968. Pp. 21-24.

4. General Purpose Simulation System/360 Introductory User's Manual. Publication GH20-0304-4. White Plains, N.Y.: IBM Technical Publications Department, November 1969; Univac 1100 Series General Purpose Systems Simulator (GPSS 1100) Programmer Reference (rev.). Publication UP-7883 Rev. 1. Sperry Rand Corp., May 1974.

5. New York State County Data Inquiry and Analysis System User Guide. Albany, N.Y.: N.Y. State Office of Planning Coordination, January 1971. Section 3.16.

6. Ibid., Section 3.14.

7. ISC Library Reference Manual. Braintree, Mass.: ISC, February 1972. Pp. 2150-51.

8. Ibid., pp. 3200-01.

9. Ibid., pp. 3250-53.

10. Ibid., p. 3300.

11. Ibid., p. 4250.

12. Ibid., p. 4300.

13. Harold S. Becker and Herbert Gerjuoy, "Trend Impact Analysis: An Application of Computer Techniques for Management of Risk in Corporate Planning and Decisionmaking." Paper presented at American Chemical Society meeting, Chicago, August 1973; Theodore J. Gordon and John Stover, "Using Perceptions and Data about the Future to Improve the Simulation of Complex Systems," Technological Forecasting and Social Change, Vol. 9 (1976), pp. 191-202, 203-205.

14. David G. Halmstad, ACT*PLUS: An Extended Actuarial Programming Language. Working Memorandum No. 103. Bethesda, Md.: Scientific Time Sharing Corp.: September 1974.

15. Gordon and Stover, pp. 191-197,202,206-211.

16. Mina Hohlen and Eli Cohen, SPSS Procedure SURVIVAL: Survival Analysis. Document No. 435. Evanston, Ill.: Northwestern Univ. Vogelback Computing Center, October 1977.

17. David Aarons and Michael Reagan, SPSS Subprogram SPECTRAL--Spectral Analysis of Time Series. Manual No. 434. Evanston, Ill.: Northwestern Univ. Vogelback Computing Center, November 1977.

18. Tutorial: An Introduction to Computer-Assisted Planning Using the Interactive Financial Planning System. Austin, Tex.: EXECUCOM, September 1978.

19. INFONET Product Description: AUTOBJ. El Segundo, Cal.: Computer Sciences Corp., May 1979.

20. ISC Library Reference Manual, p. 3100.

21. New York State County Data Inquiry and Analysis System User Guide. Section 1.1.

22. George E. P. Box and Gwilym M. Jenkins. Time Series Analysis: Forecasting and Control. San Francisco: Holden-Day, 1970.

23. Selwyn Enzer, INTERAX--Phase II. Report M-37. Los Angeles, The University of Southern California Center for Futures Research, December 1979.

24. FUTURSCAN Program Manual: Trend Impact Analysis and Cross-Impact Analysis. Report 369-01-36. Glastonbury, Connecticut: The Futures Group, June 1977.